Annual Cycle

Class Business

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Reading for this lecture

Required. Gill: Chapter 9

1. Introduction

A) ACTIVITY PATTERNS ARE NOT RANDOM

The timing of different behaviors and of major life events (e.g., breeding, migration) generally is very predictable in birds. Consequently, there are distinct patterns of activity that are repeated from day to day and year to year. For example, if you go outside to look at birds you will usually find that they are very active early in the morning, that activity drops off around midday, and then picks up again towards evening. Similarly, ornithologists and birdwatchers can predict – often to within a few days – when the first migrants of a particular species will return from their wintering grounds, or when a species will begin to lay eggs.

B) DAILY CYCLES (CIRCADIAN RHYTHMS)

i) Most birds have an "internal clock" which determines their activity patterns and physiological rhythms (e.g., metabolic rate varies with time of day).

ii) Light-dark cycles are probably the basis for this clock in most (though not all) circumstances.

ii) Generally, this clock operates on approximately a 24-hour cycle. But, the clock is not exact and needs to be constantly reset (entrained) in order to prevent it from drifting. Experiments have shown that if you deprive birds from access to normal light and dark cycles (e.g., by keeping them in dim light), their circadian rhythm will drift away from a strict 24-hour cycle (the same is true for humans).

C) ANNUAL (CIRCANNUAL) CYCLES

i) Many birds also have endogenous annual cycles, which influence the timing of major events in the annual cycle, such as when they breed, molt and migrate.

ii) As with circadian rhythms, experiments with captive birds have shown that the timing of these events occurs in a predictable way, often conforming to a 12-month schedule. Again, however, these cycles can drift if birds are placed in a constant environment. One cue that might help them entrain their cycles is patterns of varying day length.

iii) Some species also have circannual rhythms that do not match a 12-month cycle. Under what conditions would you expect this to occur? Why?

2. Control of cycles

A) PHOTOPERIOD

i) Daylight provides birds with at least two types of information. First, the mere presence of light can act to stimulate neural receptors. Second, by coupling the presence/absence of light with a circadian rhythm, birds can obtain a measure of day length (which – at least in some parts of the world – is an indicator of the time of year).

ii) **Pineal gland** (which is found in the brain) seems to control the biological clock in birds. Experimental removal of this gland causes the clock to fail.

iii) Even very small changes in photoperiod can cause physiological changes associated with breeding. Among the things that day length can influence are: gonad development (and subsequent reproductive physiology, which influences whether a bird engages in breeding behaviors such as singing), migratory behavior, molt timing.

B) LIGHT RECEPTION

i) Day length is monitored by light receptors located in the **hypothalamus** (this is different from mammals). These receptors respond to the very low light levels that penetrate into the brain.

ii) Triggering these receptors causes the production of neurohormones, which are carried to the **pituitary gland**, which then releases hormones that stimulate gonad development.

C) PHOTOREFRACTORY PERIOD

i) Following gonad development and subsequent reproduction, there is a period in many birds during which long days do not trigger the gonads to start developing over again.

ii) This **photorefractory period** is best developed in migratory species and appears to be important in timing post-breeding molt and migration activities so that they occur before conditions get too bad for birds to be able to find enough food to complete them.

3. Timing of breeding

A) BREEDING TAKES PRIME PLACE IN THE ANNUAL CYCLE

i) The timing of breeding probably has primacy in determining the sequence of major annual events (because natural selection favors those that produce most offspring).

ii) Timing of other events has to fit around the need to reproduce. On the other hand, the need to do other things in order to survive can limit the time period in which breeding can occur.

iii) In many species day length is a primary trigger. But, there are some species for which day length is not important. (Can you think of some types of birds which are unlikely to be affected by day length?) Day length also can only give an approximate estimate of when it is best to start breeding (because conditions vary from year to year), so lots of other things are used to fine-tune the system.

B) MANY FACTORS INFLUENCE WHEN IT IS BEST TO BREED

i) Food. Reproduction is an energetically expensive activity and birds need to time their breeding so that they have enough of the right kind of food to raise their young. For example, chickadees time breeding so that their young are hatching when caterpillar abundance is at its peak. Cedar Waxwings on the other hand feed their young on berries (which are not available until after most birds have finished nesting). Consequently, waxwings nest very late in the year. Some seabirds will skip breeding altogether in years when there is little food around.

ii) Water. Availability of water (or, more typically, rainfall) can affect the timing of breeding directly, and indirectly via food production. In desert areas, especially, reproduction is timed to coincide with heavy rains. In some species of desert sparrow it is so tightly tuned that birds will start singing to set up breeding territories within hours of the rains starting. In the tropics, breeding is often tied to seasonal wet-dry cycles, rather than to "summer" and "winter".

iii) Temperature. As with water, temperature can have both direct and indirect effects. Breeding tends to occur when conditions are warm. Warm conditions also tend to coincide with food production (e.g., insect and plant production increase when it gets warm). On shorter time-scales, temperature can affect prey capture: insects are easier to catch when they are cold. When conditions are warm it is easier to thermoregulate, consequently, a bird is more likely to be able to obtain excess energy that can be used for reproduction. But, there are cases when birds have evolved mechanisms that allow them to breed even when it is very cold (think: skua chicks).

iv) Habitat availability. In some cases, the mere presence of suitable nesting habitat can limit when breeding can occur. E.g., cliff-nesting arctic seabirds.

v) Behavior of others. Finally, the presence and behavior of conspecifics (= others of the same species) can be important (think: flamingos).

C) WHAT DO YOU THINK GLOBAL CLIMATE CHANGE MEANS FOR ALL THIS?

4. Timing of molt

A) NEED TO AVOID OTHER MAJOR EVENTS IN THE ANNUAL CYCLE

i) Molt is energetically very expensive (see box 11-2 in Gill), but so are other events such as breeding and migration. Breeding, for example, can increase energy needs by up to 50%.

ii) Consequently, birds generally (there are exceptions – see the text book) avoid molting while they are breeding or migrating.

B) PHYSIOLOGICAL CONTROL

i) Physiologically, the timing of molt is determined by the interaction of thyroid hormones and gonadal hormones. The latter seem to inhibit molt: molt does not begin until after hormone levels have declined and the injection of these hormones can halt molt in actively molting birds. Consequently, molt typically does not begin until reproduction is over.

ii) But we know that molt timing is not determined by gonadal hormones alone because birds continue to molt on schedule following experimental castrations.